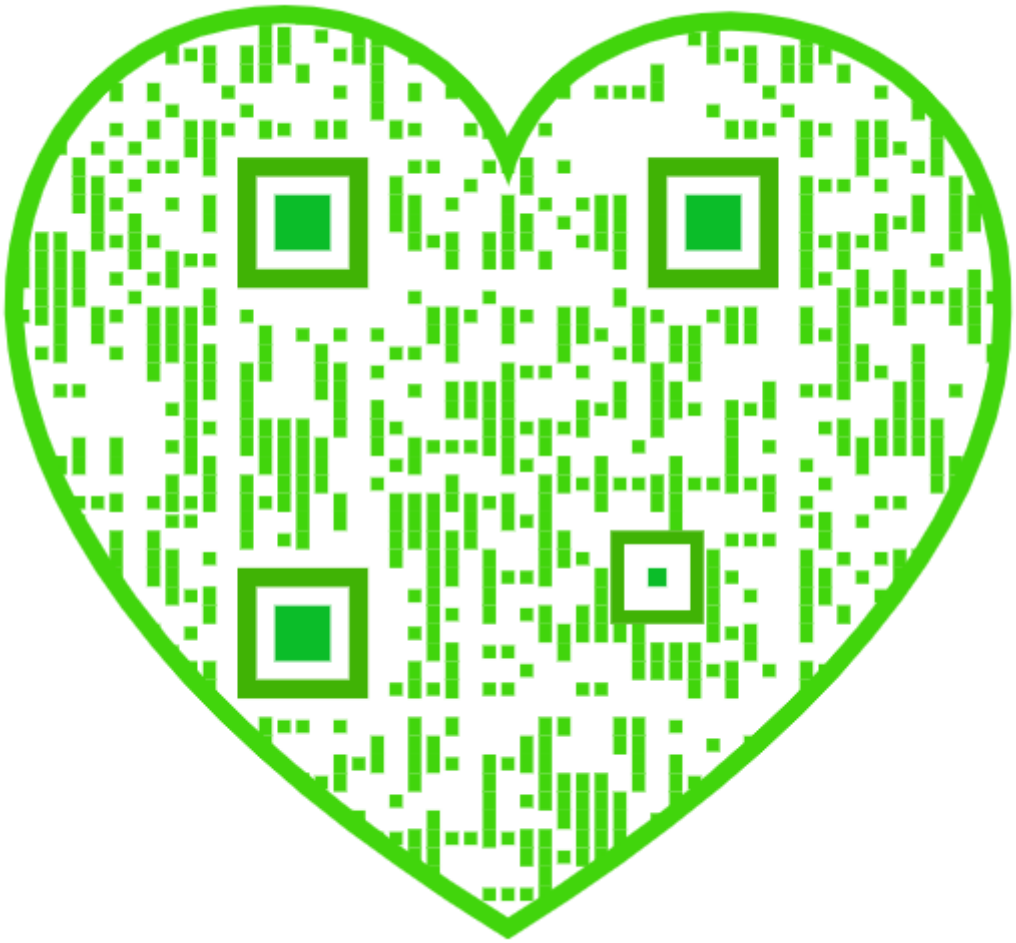

HAWAII AGRICULTURAL EXPERIMENT STATION
E. V. Wilcox, *Special Agent in Charge.*

BULLETIN NO. 22

Insects Attacking the Sweet Potato in Hawaii

BY

DAVID T. FULLAWAY,
ENTOMOLOGIST

UNDER THE SUPERVISION OF
OFFICE OF EXPERIMENT STATIONS.
U. S. Department of Agriculture.

HONOLULU:
PARADISE OF THE PACIFIC PRESS.
1911.

HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU.

[Under the supervision of A. C. True, Director of the Office of Experiment Stations, United States Department of Agriculture.]

Walter H. Evans, *Chief of Division of Insular Stations, Office of Experiment Stations.*

STATION STAFF:

E. V. Wilcox, *Special Agent in Charge.*
J. Edgar Higgins, *Horticulturist.*
F. G. Krauss, *Agronomist.*
W. P. Kelley, *Chemist.*
D. T. Fullaway, *Entomologist.*
Wm. T. McGeorge, *Assistant Chemist.*
C. J. Hunn, *Assistant Horticulturist.*
V. S. Holt, *Assistant in Horticulture.*
C. A. Sahr, *Assistant in Agronomy.*

LETTER OF TRANSMITTAL

HONOLULU, HAWAIIAN ISLANDS,
Dec. 27, 1910.

SIR:

I have the honor to transmit herewith and to recommend for publication as Bulletin No. 22 of this station a Report on the Insects Attacking the Sweet Potato in Hawaii, prepared by David T. Fullaway, entomologist. This report gives an account of the chief injurious insects of the sweet potato in the Hawaiian Islands, their life histories, habits, natural enemies, etc., and suggestions for their control. The sweet potato is one of the most important vegetables grown in the Territory and is cultivated everywhere in gardens and larger areas. On account of the fact that there is a constant market for this crop in Honolulu at a reasonable price and particularly on account of the fact that during the period from May 15 to July 15 a market is offered for sweet potatoes in San Francisco at a high price, it seems desirable to present an account of the insect troubles which growers are likely to meet, together with practical means of overcoming them. In order to assist the grower of sweet potatoes to identify the pests, a number of illustrations have been prepared and are believed to be necessary for a proper understanding of the text.

Respectfully,

E. V. WILCOX,
Special Agent in Charge.

DR. A. C. TRUE,
Director Office of Experiment Stations,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
JAMES WILSON, *Secretary of Agriculture.*

CONTENTS.

	Page
Introduction	9
Cutworms	10
Sweet potato sphinx	11
Sweet potato leaf miner	13
Sweet potato stem borer	16
Sweet potato leaf roller	19
Tortricid leaf roller	23
Sweet potato weevils	27
Minor pests	30
Beneficial insects	31

LIST OF ILLUSTRATIONS.

Fig. 1 *Agrotis ypsilon* Rott., cutworm and moth 10

Fig. 2 *Protoparce convolvuli* (Linn.), moth.....11

Fig. 3 *Pentarthron semifuscatum* Perk.....13

Fig. 4 *Bedellia orchilella* Walsm, larva, pupa and moth ... .14

Fig. 5 *Omphale metallicus* Ashm..... 16

Fig. 6 *Omphisa anastomosalis* Guenee,larva pupa and moth.....18

Fig. 7 *Phlyctænia despecta* Butl., larva, pupa and moth.....21

Fig. 8 *Amorbia emigratella* Busck, larva, pupa and moth.....25

Fig. 9 *Cryptorhynchus batatæ* Waterh., larva, pupa and adult.... 28

Fig. 10 *Cylas formicarius* 01., larva, pupa and adult 30

INSECTS ATTACKING THE SWEET POTATO IN HAWAII.

INTRODUCTION.

The present paper, dealing with the insects which attack the sweet potato in Hawaii, was suggested by the very common use made of the sweet potato among the Hawaiians as an article of food, and its adaptability to cultivation by the homesteader, the small farmer, and other classes generally, on small patches of ground unsuited to general agriculture. While the sweet potato is not usually cultivated on extensive areas, the total acreage of this crop is undoubtedly large, and the present possibility of reaching coast markets when the sweet potato is out of season there, promises not only to extend its cultivation but to make a profitable industry out of what is now a rather uncertain agricultural pursuit.

A mere list of the insects attacking a crop is without much practical value. The aim, therefore, in this study has been to present all the information available in the case of each pest. This has involved much work on life histories, habits, natural enemies, means of control, etc.

The number and variety of the pests of the sweet potato may cause wonder as to how the plant persists until the potato is formed. While the depredations of the stem borer, which is an introduced pest and apparently without natural enemies, seem of a serious nature, the leaf eaters inflict no permanent injury on the plant owing to its prolific growth; and the destruction caused by the weevils which bore into the tuber can with proper measures be prevented. Potatoes of very fair quality are constantly being produced in spite of all insect damage.

The principal pests of the sweet potato are cutworms, sphinx, leaf miner, stem borer, leaf roller, and weevils.

CUTWORMS.

These attack a great variety of crops and when in excessive numbers inflict great damage. Of the 35 or more species of native and introduced cutworms and armyworms*, only eight have been observed commonly present and injurious to field crops, namely, *Cirphis unipuncta, Agrotis ypsilon* (Fig. 1), *A. crinigera, Feltia dislocata, Lycophotia margaritosa, Spodoptera mauritia, S. exigua, Caradrina reclusa.* The others are more or less confined to the mountains and kept in check by

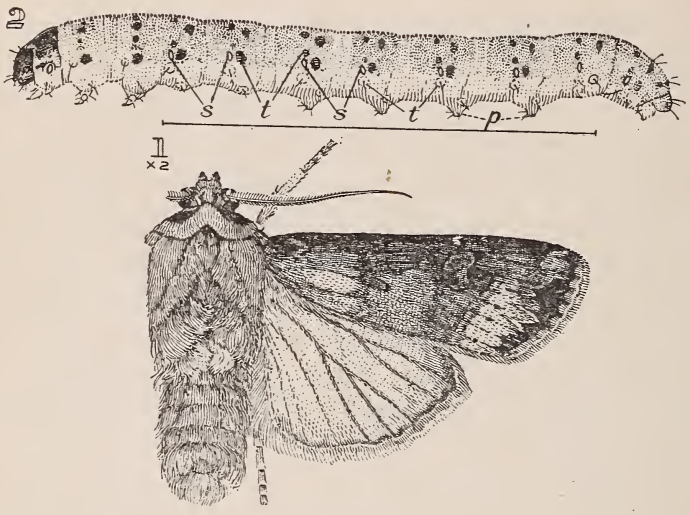

FIG. 1—Cutworm and moth, *Agrotis ypsilon* Rott. Both twice nat. size. (Copied from Swezey)

parasites. Outbreaks of cutworms are more likely to occur in the cold and wet winter months than at other times of the year. They have never been observed by the entomologist on sweet potatoes, but they are reported to attack this crop at times. They are not easily suppressed when they get beyond the control of their parasites, and in one night may clean off all vegetation to the ground in the locality where they are present. Isolated individuals are especially troublesome to seedling plants or freshly planted cuttings. They are then controlled by distributing poisoned bait (white arsenic in moistened and sweetened bran) around the plants. The natural enemies of cutworms are

* O. H. Swezey, Armyworms and Cutworms on Sugar Cane in the Hawaiian Islands. Hawaiian Sugar Planters' Sta., Div. Ent., Bul. 7.

numerous and fairly efficient. The tachinid flies *Frontina archippivora* and *Chaetogaedia monticola,* the ichneumon *Ichneumon koebeli,* and birds are especially valuable.

THE SWEET POTATO SPHINX.

The sweet potato sphinx moth (*Protoparce convolvuli*) (Fig. 2) is practically a cosmopolitan insect. The larva—one of the "horn worms"—feeds on various species of Ipomœa. It is reported to be injurious to sweet potatoes in the United States, West Indies, Madeira and Canary Islands, Australia, and India. In Hawaii it often becomes destructive to wild Ipomœa vines, completely stripping the foliage, and is at times bad on sweet potatoes. The worm is usually found on the under side of the leaf, which it devours from the edge. A large worm will eat quite a few leaves during the course of a day and may eat some of the stem.

Life history. There are four distinct stages in the life cycle of this insect—namely, the egg, larva, pupa, and adult.

The egg. The eggs of the sphinx moth are laid singly on the under side of a leaf. Thirty or forty eggs, or even more, may be laid by a single moth. The egg is sub-spherical, smooth, shining, nearly colorless, with a greenish tinge, 1.35 mm. in diameter, finely punctured and firmly attached. The egg stage occupies from 6 to 8 days.

The larva. The larva when first hatched is about 3 mm.

FIG. 2—Sweet potato sphinx moth, *Protoparce convolvuli* (Linn.) nat. size. (Copied from Froggatt)

long, faintly greenish, almost white, with a black horn, the head pale greenish yellow. The entire larval stage covers about thirty-two days, in which time the worm increases in length to

115 mm. and proportionately in breadth. It molts four times and in the fifth larval instar has the characteristic and handsome appearance of the sweet potato worm. The color is very variable, and may be any shade of green or brown, from very light to very dark, almost black. The green form is thus described by Dyar*:

Head higher than wide, rounded, flat in front, smooth, shagreened; leaf green, with a broad, black, vertical band on each side covering the ocelli, which it just encloses by its well-defined anterior border; before it the ground color assumes a yellowish tint and preceding this yellowish shade is a faint, blackish clouded band; width 6 mm. Body plump and robust, the segments annulated; head slightly retracted below joint 2, and joint 2 below joint 3, but body elsewhere of uniform size. Horn large, tapering, curved backward, covered with short tubercles which bear very minute setae. Body smooth, colored leaf-green, a little mottled with whitish, with the following purplish brown mottled marks: a patch covering the thoracic feet and their bases; an oblique, subventral patch on joint 6 analogous to the marks covering the abdominal feet, each of which extends upward and forward obliquely in a broad band ending at the anterior border of the segment; the one covering the anal foot extends along subventrally to the anterior edge of joint 11; subanal plate green, contrasting with the nearly black bases of the feet, bordered above by a faint brown subdorsal shade; a broad, subdorsal band enlarged centrally on each segment, begins behind the cervical shield, widens and sends out an arm obliquely forward and downward on joints 5-11, each of which ends at the anterior edge of the segment before the spiracle. The band narrows on joint 11 posteriorly and ends at the horn, which is colored blackish brown with small greenish tip. The lateral branches of the subdorsal band are edged posteriorly with white, representing the usual oblique stripes; spiracles black, with a linear ochreous border and central dividing line, those on joints 5-12 surrounded by a circular black patch, contiguous (except on joint 12) to the oblique lateral lines. Length about 115 mm., of horn 7 mm.

When fully grown the larva usually contracts, lying on the surface of the ground or burying itself beneath the surface. The writer has not noticed that it constructs a cell. The larva ceases feeding perhaps five to six days before pupating. It is interesting to note that all the stages are shorter in Hawaii than in colder climates. Poulton† records the cycle from egg deposition to mature larva as occupying 61 days, while these stages cover a period of only 40 days in Honolulu.

The pupa. The pupa is stout, about 55 mm. long, and brown.

---

* Ent. News, 6 (1895), pp. 95-97.

† Trans. Ent. Soc. London, 1888, p. 550.

The tongue-case is quite long, extends away from the body and recurves about 22 mm. from its origin, the distal end lying on the body and forming the so-called "jug handle." The pupa is usually found in the ground. The pupal stage occupies 20 to 28 days.

The moth. The moth has the usual sphinx appearance, i.e., heavy body, large eyes, stout, narrow, pointed wings, thickened antennæ, stout, rounded abdomen tapering to a point, and is crepuscular in habit. It measures 45 mm. in length, 90 mm. in wing expanse, is of a generally dark gray color mottled with brown and black; the abdomen has a broad grayish brown dorsal stripe with short, transverse, whitish or pinkish bars on either side. The cheeks and venter are whitish, the antennæ grayish.

Remedies. When the sphinx moth caterpillars become a pest they may be controlled by hand picking or by the use of a poison to be sprayed on the foliage. Lead arsenate is perhaps the safest and most effective insecticide to use in this case. The species is kept in check by a hymenopterous fly, *Pentarthron semifuscatum* Perkins (Fig. 3), which parasitizes the egg. Dr. Perkins states that the larvæ are also decimated in the younger stages by parasites, presumably Echthromorpha and tachinid flies.

FIG. 3—*Pentarthron semifuscatum* Perk., parasitic on eggs of sweet potato sphinx. 55 x nat. size

THE SWEET POTATO LEAF MINER.

The genus Bedellia (Tineidæ) is represented in these islands by seven species, the larvæ in all cases being leaf miners. *B. somnulentella* and *B. minor* mine the leaves of species of Ipomœa, *B. oplismeniella,* leaves of a grass (*Oplismenus compositus*), *B. boehmeriella,* the leaves of *Boehmeria stipularis.* The host

plant of the other three species is not known except that the leaf miner commonly found in sweet potato leaves around Honolulu is, on the authority of Busck, *B. orchilella* (Fig. 4), and not the commoner *B. somnulentella* or *B. minor*. *B. orchilella* is not known outside of the Hawaiian Islands, *B. minor* is recorded from Florida and the Hawaiian Islands, and *B. somnulentella* has a wide distribution, occurring in Europe, the United States, Australia, New Zealand, Canary Islands, Madeira Islands, and Hawaiian Islands.

The injury is done by the larva or caterpillar, which soon after hatching penetrates the epidermis of the leaf and feeds on the mesophyl, the green tissue lying between the upper and lower epidermis. When small the caterpillar eats only the tissue in front of it, constructing a tunnel or mine as it proceeds. These tunnels are usually quite long and may be more or less straight, or cross and recross themselves, forming a complicated network. The mines or tunnels are plainly indicated by the discoloration of the leaf along their course. In its feeding a caterpillar may abandon one mine and begin another in a fresher

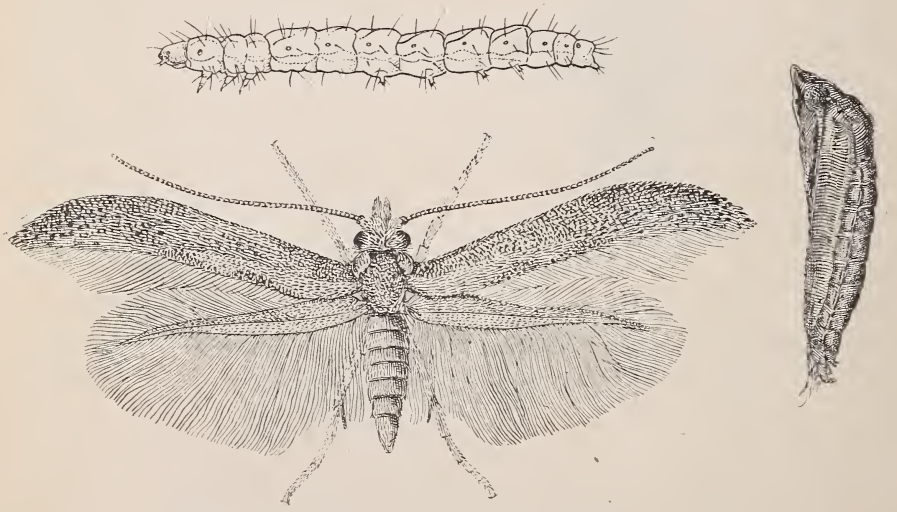

FIG. 4—Larva, pupa and moth, *Bedellia orchilella* Walsm. The larva is the sweet potato leaf-miner. 14 x nat. size.

portion of the leaf. While moving about on the surface from one location to another, they progress with a peculiar looping motion. When nearly mature the caterpillars eat the tissue all

around them, and not moving far away from the entrance to their burrow, the castings are ejected, forming small tufts of black excrementitious matter. They pupate externally, forming a characteristic case which is supported in a web, or fastened to the leaf by fine silken strands secreted by the larva prior to pupation.

When the leaf miner is abundantly present in a field, the plants usually have a seared or withered appearance, but are apparently not materially injured because of their rapid growth.

Life history. There are four distinct stages in the life cycle, namely, the egg, larva, pupa, and adult.

The egg. The eggs are laid singly, usually on the under side of a leaf, sometimes on the upper side, in a crevice alongside a leaf-vein. Apparently a number are laid by a single moth. The eggs are nearly white to reddish and highly iridescent, flattish, elliptical, .3 mm. by .2 mm., coarsely reticulate. The egg stage occupies about 8 days.

The larva. The larva when hatched is about .36 mm. long, pale green, head and cervical shield colorless, shining, segmentation distinct, setæ inconspicuous. The larva molts several times before attaining its full growth. When full grown it is about 7 mm. long, pale greenish, head, cervical shield and anal shield almost colorless, having a slightly brownish tint, the segmentation marked. Tubercles slightly fuscous, minute, each with a seta, arranged in longitudinal rows, (2) a little more removed than (1), (3) above spiracle, (4+5) below, (6) a trifle anterior, (7) ventral; spiracles concolorous. The larval stage occupies 10 days.

The pupa. The pupa is angular, 3.5 mm. long, dark green when first formed, turning to light brown with black spots and suffusions. Head with pointed projection in front black; horns and eyes black. Wing-cases extending to apex of ninth abdominal segment, third pair of legs a trifle further, antennæ to apex of tenth segment, all fuscous. Cremaster forked and armed with minute recurved spines, which are also found laterally on abdominal segments to sixth. A central longitudinal ridge on dorsum. The pupal stage occupies 6 days.

The moth. The moth is described as follows*:

Antennae brownish fuscous, with whitish annulations. Palpi, head and thorax greyish fuscous; face paler. Forewings greyish fuscous, with some pale cinereous speckling throughout; the only indication of markings is in the absence of the pale speckling at the base of the fold, in a slight spot on the outer half of the fold, and in a short dark streak on the dorsum, but these markings are very obscure: cilia pale greyish fuscous. *Exp. al.* 7 mm. Hind-wings dark grey; cilia fuscous. Legs greyish fuscous, with whitish tarsal speckling.

Remedies. It would be difficult to control the leaf miner by artificial means, such as the application of a poisonous mixture to the leaves, as the larvæ feed within the leaf, not on the surface. The arsenical sprays applied for other leaf-feeders, however, might contribute to lessen the infestation of leaf miner. Leaf miners are fairly well kept in check by the chalcid *Omphale metallicus* (Fig. 5), which parasitizes the larva. Another eulophid (*Pediobius*) has been bred from leaf-miner material and may be either secondary or primary.

FIG. 5—*Omphale metallicus* Ashm., parasitic on sweet potato leaf-miner. 30 x nat. size.

THE SWEET POTATO STEM BORER.

The sweet potato stem borer (*Omphisa anastomosalis*) (Fig. 6) is not a native insect but apparently a recent introduction from China. Its habitat as given by Hampson is China, Sikhim, Khasia, Nilgiris, Ceylon, Burma, Andamans, Java, Duke of York Island, and it evidently belongs to the Indo-Malayan region. It was first observed in Hawaii about 1900. Since then it has been increasing, and promises to be a serious pest if it is not checked by natural enemies.

---

* Walsingham, Microlepidoptera. Fauna Hawaiiensis, vol. I, pt. 5, p. 725. Cambridge, 1907.

The injury results from the larva or caterpillar's boring the stems of the plants, causing them ultimately to wilt and die. Full-grown caterpillars are usually found near the base of the stem with a long tunnel behind them. The thick mass of decayed stems beneath the verdant foliage of the sweet potato is largely the result of the stem borer's work. The borers sometimes get into the potato, in which case the damage is even more serious.

Life history. There are four stages in the life cycle, as with the other moths—the egg, the larva or borer, pupa, and adult.

The egg. The eggs are laid singly or two or three together, usually in the crevices on the stems, sometimes on the leaves. They are elliptical (sometimes irregular), flat or moderately rounded, measuring .63×.50×.35 mm., pale green, finely reticulated on both surfaces. They hatch within 5 to 6 days of deposition.

The larva. The larva just after hatching is 1 mm. long, sordid white (the contents of the alimentary tract green beneath), head bilobed, black, and a black shield-shaped marking on cervical shield. Hairs conspicuous. Soon after hatching, the larva bores into the stem, a small tuft of ejected material indicating the point of entrance. The larval stage occupies 27 to 30 days, in the course of which several moults are undergone. The full-grown caterpillar is described by Swezey* as follows: "Length about 30 mm., width about 3½ mm., head 2 mm., color pale yellowish white, with conspicuous brown, very broad and flat tubercles; head yellowish brown, ocelli black except the two upper and the lowest one, which are white, mandibles black, a black line on postero-lateral margin of head; dorsal tubercles of two rows beginning with segment three, in each row, two per segment except segment four; a row of tiny tubercles, one per segment, just antero-ventral to each of the anterior dorsal tubercles in segments five to twelve; the spiracles of segments five to twelve have a group of four tubercles surrounding each; by their union on some segments there are but three of these; a similar cluster of tubercles occupies the position corresponding to spiracle on segments three and four; a

* Proc. Hawaiian Ent. Soc., 1 (1906), pt. 2, p. 76.

line of tubercles just dorsal of the base of the feet; four ventral tubercles on segments 5, 6, 11, 12 (those segments having no feet); the ventral tubercles have two or three hairs, others mostly but one, a few hairs on the head also."

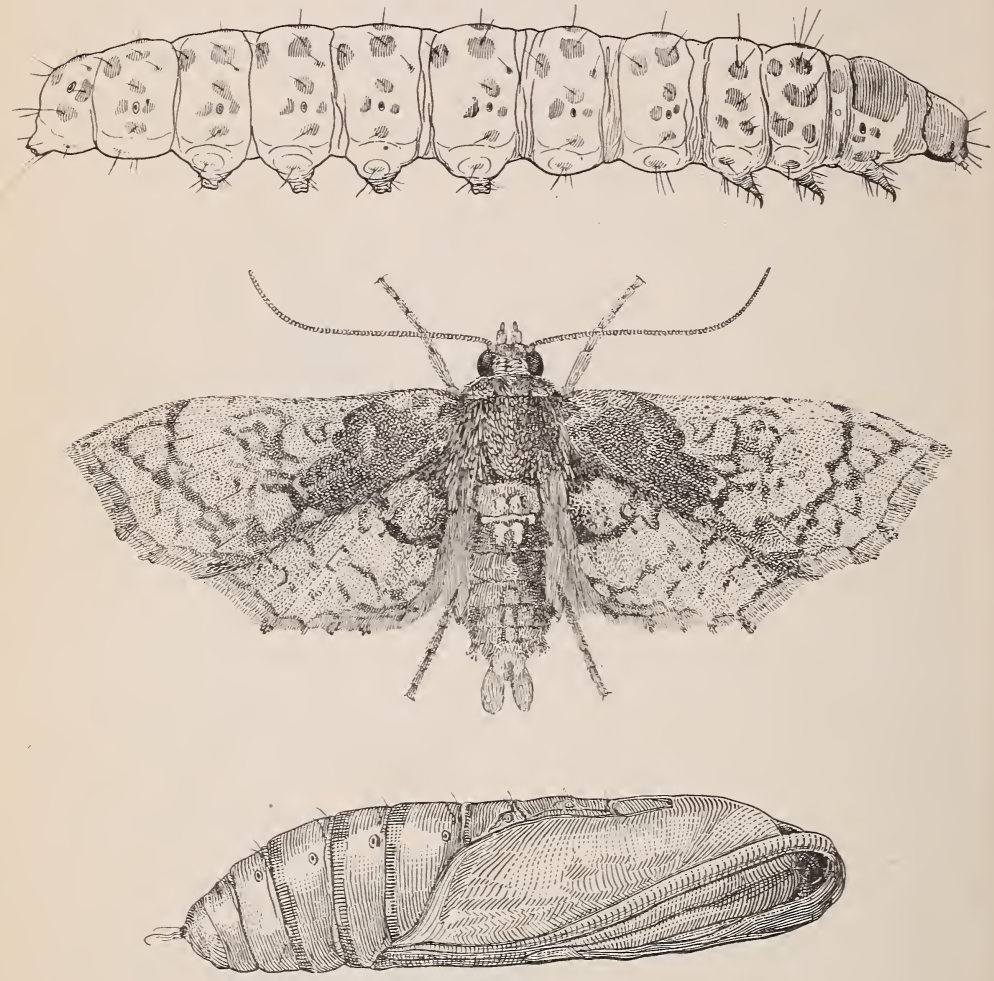

FIG. 6—Larva, pupa and moth, *Omphisa anastomosalis* Guen. The larva is the sweet potato stem-borer. 3 x nat. size.

The pupa. Pupation takes place in the stem near an exit from the burrow. The pupa is found in a slender web-like cocoon. It is described as follows: "16 mm. long and 3 mm. wide, nearly cylindrical, abruptly tapering at the two posterior segments; uniform medium brown, a slightly darker band on posterior margin of abdominal segments; tiny short hairs where

there were hairs on the larva; wing-cases a little pointed, extending to posterior margin of fourth abdominal segment, one pair of leg-cases extends a little farther, about half-way on the fifth segment; cremaster very short, blunt, with a few hooked spines." The pupal period is 16 to 18 days.

The adult. The following is a description of the moth*:

White, the head, thorax, and abdomen suffused with ochreous and rufous, leaving some paired pale spots on dorsum. Forewings with rufous suffusion on basal area extending below median nervure to middle of wing; hyaline patches at middle and end of cell, with a rufous-edged ochreous spot between them; a large rufous-edged ochreous patch beyond the cell; the outer area more or less irrorated and suffused with rufous; the veins rufous; a curved postmedial rufous line with an irregularly dentate line beyond it enclosing a series of hyaline patches; a marginal rufous line. Hind-wing with the base rufous; a dark-edged rufous irregular discocellular mark with line from it to inner margin; the outer area irrorated with rufous; two irregularly waved rufous post-medial lines; the apex, anal angle, and a marginal line rufous. Expanse 32-36 millim.

The moth is rather sluggish and slow to take the wing.

Remedies. No very effective remedy can be suggested for the stem borer, as most of the life of the insect is passed within the stem. The freshly hatched larvæ might be reached with an arsenical poison, and the moths can be trapped. Where sweet potato fields become badly infested, so that the crop becomes unprofitable, moving to a new location would seem to be the most practical course to pursue. An ichneumon fly, *Pristomerus sp.,* has been bred from the larva, but to what extent it parasitizes the stem borer is not known.

THE SWEET POTATO LEAF ROLLER.

The sweet potato leaf roller (*Phlyctaenia despecta*) (Fig. 7) has only recently been observed to attack sweet potato plants, although it is common in the mountains on wild species of the genus Ipomœa. It is evidently an indigenous insect that is accommodating itself more or less to the conditions under which the cultivated species are grown. It occurs on all the islands.

The larva or caterpillars of all the Phlyctænias are leaf rollers or feed in a depression or groove of a leaf beneath a web.

* Hampson, Moths. Fauna British India, vol. 4, p. 382 (fig. 207). London, 1896.

Those of *P. despecta* feed on the under side of leaves, eating through to the epidermis of the upper surface, and their castings are scattered about in the filmy texture of the web. The young caterpillars move about in feeding, making a number of small abrasions. Maturer larvæ feed over a continuous surface, and when they are at all numerous they leave the foliage badly skeletonized.

Life history. There are, again, four stages in the life cycle—the egg, larva, pupa, and adult.

The egg. The eggs are laid singly on the upper surface of leaves, usually beside a vein. They are oval, flattish, about .65 mm. × .45 mm., greenish, iridescent, and finely reticulated. The egg stage covers about 8 days.

The larva. The larva when first hatched is about 2 mm. long, very pale (the contents of the alimentary tract green beneath), mandibles brownish. There are no visible markings, but the hairs are conspicuous. In the course of its growth the larva molts three or four times. The full-grown caterpillar is described by Blackburn as follows*: "Convex, broad in the middle and much narrowed at the ends; each segment individually also narrowed behind and in front; green, almost concolorous, save that the dorsal line is darker; a few long hairs on each segment." This description could be amplified as follows: Length 17 mm., head rounded, faintly bilobed and with cervical shield pale, mandibles and tips of antennæ brownish; on either side of dark green dorsal vessel an irregular white longitudinal line, due to the reflection of light from the opaque fat body; a few black spots on head and cervical shield as follows: on head, two, close to median margin of the lobe, one near posterior border, the other about half-way down face, a large one on lateral margin dorso-ventrally about midway between the other two; close to and slightly back of it a group of four minute spots; below it the ocelli, the lower three of which are bordered with black; on cervical shield four small spots in a longitudinal line on the dorsum somewhat removed from median line—sometimes coalesced in groups of two; tubercles of moderate size, sub-circular, somewhat convex, con-

* Ent. Mo. Mag., 19 (1882), p. 56.

colorous with body, each bearing a seta (sometimes two), arranged more or less in longitudinal rows on each side of the body as follows: on dorsum a row (1+2) a little removed from the median line—on segments 5 to 12 two per segment, the anterior (1) near anterior margin, the posterior (2) at about center of segment—on segments 3 and 4 (1) is ventrad of (2) and both are double tubercles; a row just above the spiracles (3); a row of double tubercles just beneath the spiracles (4)—

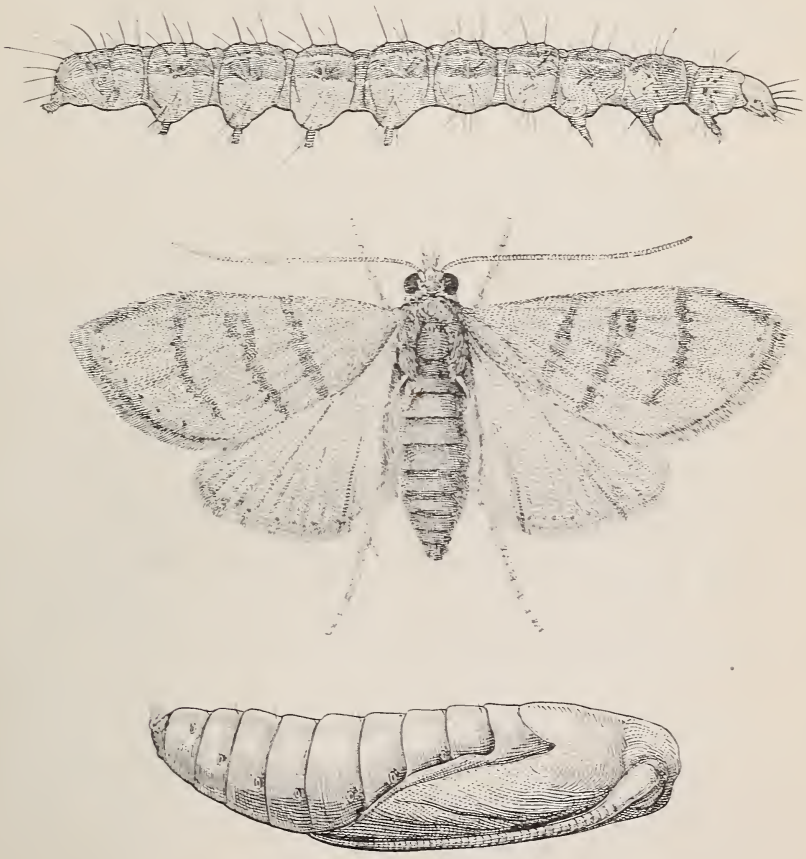

FIG. 7—Larva, pupa and moth, *Phlyctænia despecta* Butl. The larva is the sweet potato leaf-roller. 4 x nat. size.

on segments 3 and 4 this tubercle is on a line with the spiracles and anterior in the segment while (3) is on a line with it and posterior in the segment—on segment 2 there is only one tubercle, in front of the spiracle; a row (5) just below (4) and posterior in the segment—on segments with legs it is at the

outer base of same, and on segment 2 is double; a row (6) on outer side of each proleg about half-way down the leg, on the inner side of each true leg, and ventrad to (5) on legless segments—each tubercle has three setæ; a row (7) of small tubercles close to median ventral line, one to each segment—on segment 2 a number of small tubercles dorsally; spiracles brownish. The larval stage occupies 15 to 18 days.

The pupa. The pupa is formed in a slight cocoon within the folded leaf. It is brown, 7.5 mm., wing-cases extend to posterior margin of fifth abdominal segment, antennal cases a trifle beyond, and leg case to about the middle of the seventh. Stigmata on third and fourth segments conspicuously larger, projecting from the body and very knob-like. Cremaster short, truncated, and with eight hair-like hooked spines fastened into cocoon. The pupal period is 9 to 10 days.

The adult. The adult moth is described as follows*:

♂ ♀ 15-27 mm. Head, palpi, and thorax ferruginous, sometimes infuscated, palpi 3-3½, white towards base beneath, thorax sometimes suffused with ochreous-yellowish posteriorly. Abdomen grey, sometimes suffused with ochreous-yellowish or ferruginous. Legs whitish, sometimes more or less variably suffused with ferruginous. Forewings reddish-ochreous or fuscous-ochreous or ferruginous, sometimes much mixed with dark fuscous, especially towards costa on anterior half, sometimes much tinged with coppery-purplish; first line dark fuscous, bent in middle but usually obsolete on costal half; roundish orbicular and 8-shaped discal spot outlined with dark fuscous; second line waved or denticulate, dark fuscous, more or less curved on upper portion, sometimes sinuate near costa, below middle with an abrupt semicircular excavation inwards beneath discal spot; posterior half of costa sometimes spotted with dark fuscous; a terminal series of dark fuscous or blackish dots; cilia rather dark fuscous, tips obscurely whitish. Hind-wings fuscous, darker posteriorly, sometimes mixed with lighter ochreous suffusion; two obliquely placed dark fuscous discal dots; usually an indistinct darker postmedian line as in forewings; a terminal series of blackish dots; cilia grey or grey-whitish, with dark grey subbasal line.

Remedies. This moth is at times very injurious to the sweet potato but is usually well controlled by parasites. The application of arsenate of lead is recommended in case of a troublesome appearance of the caterpillars. The writer has bred *Limnerium blackburni* from the larvæ of these moths in great num-

* Meyrick, Macrolepidoptera. Fauna Hawaiiensis, vol. 1, pt. 2, p. 217. Cambridge, 1899.

bers, and it seems to be an effective parasite. Dr. Perkins has also bred *Chelonus blackburni* and *Chalcis obscurata*. A common Odynerus wasp (*O. nigripennis*) has been observed gathering the caterpillars.

THE TORTRICID LEAF ROLLER.

The tortricid leaf roller (*Amorbia emigratella*) (Fig. 8) is an introduced pest which has been known in Hawaii since about 1900. It occurs also in Mexico and Costa Rica, and was probably brought here from the former country. It has increased very rapidly, as most introduced insects do which are not checked by parasites, and its great range of food plants makes it an unusually destructive form.

The larvæ are leaf rollers on many kinds of plants, shrubs, and fruit trees, and are often so numerous as to defoliate trees, on some of which it attacks the fruit as well. The writer has found it on citrus trees, cotton, avocado, guava, rose, passion flower vine, tomato, papaya, cacao, as well as on sweet potato, and on various indigenous plants in the mountains.

The young larvæ feed much as do the small caterpillars of *P. despecta*, working beneath a coarse web. In fruits they commence to bore inside, but soon desist and work on the surface beneath a web, or fasten the fruit to the nearest object—a leaf or another fruit. They destroy the blossom in the papaya and prevent the fruit from setting.

Life history. There are four stages in the life cycle—the egg, larva or caterpillar, pupa and moth.

The egg. The eggs are laid in clusters of from 65 to 120 (sometimes only a few eggs in a cluster), usually on the upper surface of a leaf, sometimes on foreign bodies. The cluster imparts a greenish color and has a whitish protective covering which extends beyond the edge of the egg-mass. The eggs are flat, elliptical, 1 mm. long, slightly iridescent and finely reticulated (which becomes more apparent after hatching) and overlap a trifle. The greenish color changes to brownish as the ovum approaches maturity, and just previous to hatching the young larva may be seen coiled inside the egg. The egg stage occupies 10 days.

The larva. The larva on hatching is about 1.65 mm. long,

light green, head brownish-yellow, cervical shield lemon-yellow. On each segment a pair of dorsal hairs which are longer on the head, cervical and anal shields. The eyes are black, mandibles dark brown, anal shield concolorous. In the course of its growth the larva molts three or four times. Full-grown larva 25 mm., head rounded, slightly bilobed, luteous, with a pair of dorsal and lateral pinkish-brown bands, a black line on lateral margin extending nearly its whole length, ocelli black, pale centered, continued caudad in a wavy black line, tips of mandibles dark brown, tips of antennæ brownish-black; body stout, cylindrical, uniform green or yellowish-green, transversely wrinkled, fat body and tracheæ showing conspicuously through thin integument; tubercles small, slightly convex, concolorous with body or slightly fuscous, each bearing a seta (sometimes two), arranged in several longitudinal rows as follows: on dorsum anterior (1) and central (2) near anterior margin and center of segments 5 to 12, the former near median line—on segments 3 and 4 these tubercles double and (1) ventrad of (2); supra-spiracular (3) one situated just above each spiracle (on segment 12 pre-spiracular); sub-spiracular (4+5) a double tubercle below each spiracle, composed of two tubercles united and bears two hairs—on segment 2 in front of spiracle—on segments 3 and 4 (1), (4+5) and (3) form a triangle in about median position in the segment, (1) double; lateral (6) one on each segment caudad of (4+5), nearer to posterior margin —on second segment double and ventrad of (4+5); marginal (7) on outer side of each proleg and inner side of each true leg—on legless segments in about the same longitudinal line ventrad of (6)—each has three setæ; ventral (8) a small tubercle near median ventral line of each segment; cervical shield concolorous with body, with black line on lateral margin; feet concolorous with body, the tips black; spiracles minute, circular, rimmed with brown and center yellowish-white—those on segments 2 and 12 larger than the others. The larval period is 28 to 35 days.

The pupa. Pupation takes place within the folded leaf. Pupa 9 to 12 mm., dark brown on dorsum shading into golden-brown on venter; wing-cases luteous, and extending beyond middle of fourth abdominal segment; spiracular openings

small, reddish-brown; on dorsum of abdominal segments 2 to 8 two transverse rows of minute blunt spines, near anterior and posterior margins, becoming smaller outwardly from median

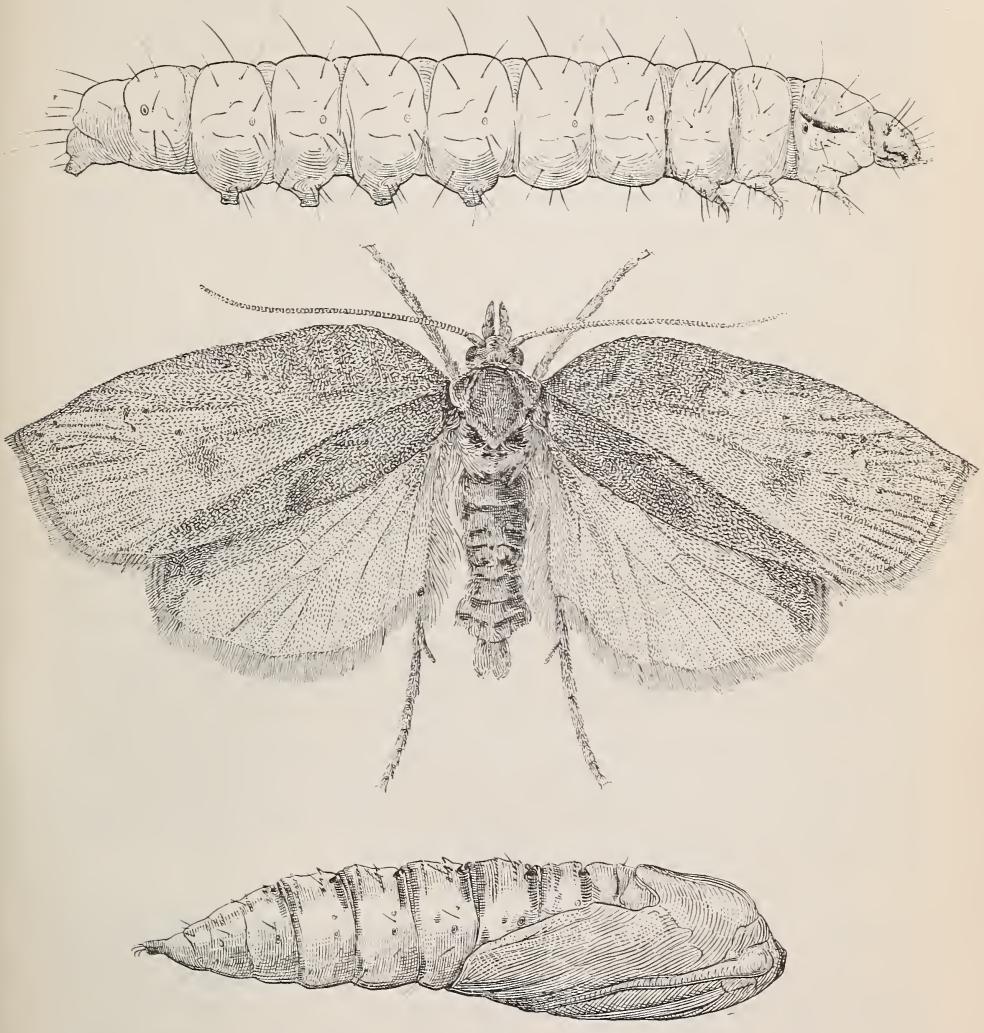

FIG. 8—Larva, pupa and moth, *Amorbia omigratella* Busck. The larva is the tortricid leaf-roller. 4 x nat. size.

line and disappearing before the spiracles; posterior row a trifle more extensive than the anterior; in front of anterior row on median line of dorsum of segments 2 to 7 a pit, partially covered by narrow blackish lip extending from posterior margin of preceding segment; on segment 9 a few scattered hairs; cre-

master moderately pointed with eight short recurved spines. The pupal stage covers 10 days.

The moth. The moth is described by Busck as follows*:

Female. Basal joint of labial palpi short, ochreous; second joint long prorected, rust-red with a violaceous sheen on the tip; terminal joint short, reddish brown, shaded with black. Face behind the palpi short-scaled, whitish; head reddish brown, mixed with ochreous and with a short pointed frontal tuft. Antennae reddish brown, simple. Thorax and patagia uniformly dark brown. Forewings with base of costa strongly arched; costal and dorsal edges nearly parallel; apex squarely pointed; termen slightly sinuate below apex, thence evenly rounded; ochreous brown, shading into light ochreous on the terminal third; the edge between two colors is not sharply drawn, but the limits are still quite distinct, the lighter color occupying the area below a straight line from basal fourth of the dorsal edge to apex. From just before the middle of costa runs an indistinct, dark bluish-gray band obliquely outward towards tornus, but fades out in the ochreous part of the wing and is even interrupted in the brown costal part; parallel with this is another similarly colored, but less distinct streak at apical third, also disappearing in the light portion of the wing. On the dorsal edge at basal fourth and at the middle are two short dark gray streaks, parallel with the costal streaks. The entire wing is finely mottled with a close transverse apparently darker striation, which is produced by transverse rows of slightly elevated scales. These markings are of varying intensity in different specimens, some showing hardly any trace of the darker cross-bands and having the ground-color lighter and nearly unmottled except for the fine transverse striation caused by the slightly raised rows of scales. Hindwings light straw-yellow, with the apex mottled with dark brown and black and with the costal cilia absent and abruptly beginning again just before the tip of the wing. Cilia straw-white. Underside of the forewings reddish ochreous, with a blackish terminal line before the cilia. Abdomen light yellow. Legs straw-yellow; the anterior and middle legs shaded with reddish brown exteriorly and with the tarsi faintly annulated.

Alar expanse 27 to 29 mm.

Male. Of considerably smaller size and of a general lighter color. Forewings nearly uniformly light ochreous without the darker basal and costal shade. The first costal dark streak is represented by a dark bluish brown triangular spot, terminating in a nearly black dot; the second costal streak is replaced by a faint, curved, dark line, emitted from a small bluish brown costal spot. The transverse striation caused by the rows of slightly raised scales is apparent. The antennae are pectinated.

While the two males from Hawaii before me do not exhibit much variation, a similar range of variation as is found in the females may be expected in the males.

Habitat. Tantalus and Makiki, Oahu, Hawaiian Islands. O. H. Swezey, Collector.

---

*Proc. Ent. Soc. Wash., 9 (1909), p. 201.

Remedies. On account of the many leaf-feeding caterpillars, sweet potatoes must be sprayed four or five times during the year with an arsenical poison. The attacks of hornworm and Phlyctænia, which seem to be more destructive of the foliage than the others, will determine when this spraying is to be done, and the remedy for these pests will also be effective against the others. Arsenate of lead is recommended as the most useful form of arsenic and the one the least likely to burn the foliage. The tortricid leaf roller is parasitized by *Chalcis obscurata,* which does something to mitigate its destructiveness. Unfortunately the very valuable egg parasites (*Trichogramma* spp.), which contribute more than any others to keep this class of pest in check, are unable to penetrate the tough covering of the *Amorbia* eggs.

THE SWEET POTATO WEEVILS.

There are two weevils attacking the tuber or rootstock of the sweet potato in Hawaii. They are quite distinct insects; one small, square-bodied, dark grayish brown, and the other long, slender and metallic. They are both introduced pests and are quite destructive at times.

The smaller one is the insect recorded in the Fauna as *Hyperamorpha squamosa* Blackburn and at another time determined as a native Acalles. It is now believed to be the common West Indian form, *Cryptorhynchus batatae* Waterhouse (Fig. 9). It is the commoner of the two in Hawaii, and the author has found it infesting sweet potatoes from Maui and Oahu, but did not find it generally prevalent. The following description is copied from Ballou*:

Cr. oblongo-ovatus, nigro-piceus; squamosus, supra spinulus erectus nigris et pallidis obsitus; *rostro* brevi, crasso, arcuato, ruguloso-punctato, carinato; *thorace* ruguso-punctato, setis (plerumque nigris) obsito, postice squamulis flavidis marginato, dorso linea, punctisque parvulis, albis, notato; *elytris* ocellato-punctato striatis, interstitiis fere planis, fusco, nigro, alboque variegatis, plaga communi, transversa, sordide alba, subapicali, ornitis; *femoribus* indistincte dentatis; *scutello* minutissimo.

Long. corp. 2 lin. Hab. Barbados.

---

* H. A. Ballou, The Scarabee of the Sweet Potato. West Indian Bul. 10 (1909), No. 2, p. 180.

This is a minute species of *Cryptorhynchus*, and differs somewhat from the type of the genus—if we regard the *C. lapathi* as such—though not sufficiently, as it appears to me, to require removal from that section. Its form is more elongated, and its scutellum is so minute as to require the aid of a strong lens to detect it; the insect nevertheless has well-developed wings; the rostrum is stouter, and subdepressed, and is inserted in a very deep rostral groove, which terminates

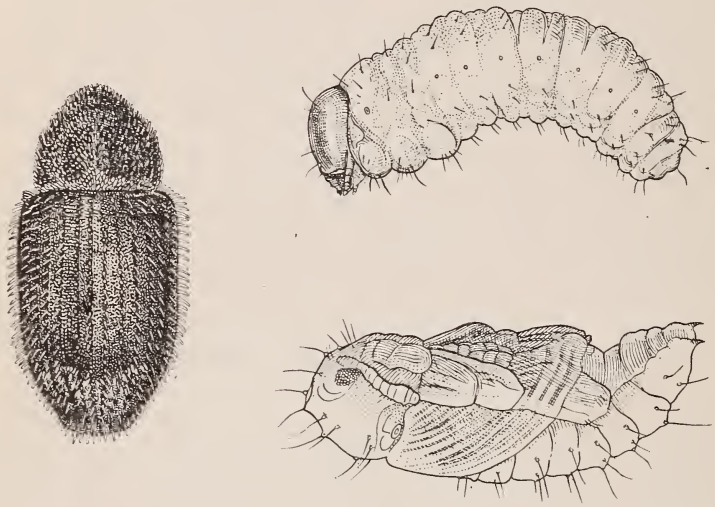

FIG. 9—Larva, pupa and adult, *Cryptorhynchus batatæ* Waterh., a common sweet potato weevil. 12 x nat. size.

between the coxae of the anterior pair of legs; the scape of the antennae is shorter and stouter, the basal joint of the funiculus is also stouter, the second joint is of an elongate obconic form, the remaining joints are also obconic, but very short; the club is tolerably developed, and of a short ovate form; the femora are rather less stout, and very indistinctly toothed beneath.

The head is covered chiefly with pale scales, but has two black spots; the thorax is rather broader than long, rather suddenly contracted in width from the middle to the fore part, and with the lateral margins of the hinder half nearly parallel, being very slightly rounded; the upper surface is densely beset with short, stiff, erect bristles, which are most of them black, but some few are white, and are aggregated in parts so as to form small spots and a white mesial line; the hinder margin is clothed with orange-yellow scales, and these form a small spot near the scutellum. The elytra are more than three times the length of the thorax, and about half as wide again, the humeral angle is rounded, the sides nearly parallel, except towards the apex, where they are rather suddenly contracted, and obtusely rounded; they are covered with scales, some of which are dirty white, others brown, and others black, producing a variegated appearance; in each of the tolerably large punctures of the striae is a white scale; on the fourth interstice from the suture is a small white spot, which is rather more con-

spicuous than others; it is situated above the middle of the elytron, and at a short distance from the apex of the elytra is a conspicuous transverse dirty white patch, in which is a waved black line. Besides the scales there are scattered dark and pale hairs on the elytra. On the under parts of the insect are scattered pale scales. The limbs are clothed with setiform scales, most of which are pale.

The eggs of the weevil are laid on the surface of the sweet potato and the larvæ or grubs bore into the interior. The larval stage is somewhat prolonged and is passed entirely within the potato, which becomes badly riddled and decayed. The larvæ pupate inside and later the adults emerge. This insect has not so far been bred at the station so as to get the length of time required for the different stages.

Remedies. This insect is very common in the Barbados and Antigua of the Lesser Antilles and is often very destructive. Experiments have been made there with vaporite, carbon bisulphid, corrosive sublimate, and arsenic, as a mean of controlling the pest, but they were found to be totally ineffective. They recommend, as the only measure of practical value, the destruction of all infested potatoes and the trash above ground by burning it in lime. In the case of a repeated recurrence of the weevil in sweet potato fields, it would be advisable to plant in another locality.

The larger of the weevils is the widely distributed *Cylas formicarius* (Fig. 10), a native probably of Cochin China, but now found in India, China, Madagascar, Southern United States, West Indies, Northern Australia—and generally over the Tropics. It is not very common in Hawaii. It breeds in stems of *Ipomoea pes-caprae,* which grows everywhere along sandy beaches, as well as in the sweet potato. The occurrence of this weevil at Lahainaluna, Maui, in January, 1907, brought it into prominence as a pest in Hawaii and the insect was discussed by Van Dine in the Annual Report of this station for that year. The following is a description of its appearance and life history*:

The beetle is somewhat ant-like in form. The color of the elytra [wing covers] and of the head and beak is bluish black; that of the prothorax is reddish brown. The yellowish-white oval eggs are laid in small cavities eaten by the parent bettles near the stem end of the tuberous roots. The milk-white larvae bore little tunnels through the

* Hawaii Sta. Rpt. 1907, p. 29.

root in all directions, so that the vine dies; and frequently the entire potato is tunneled; these burrows become filled behind the larvae with excrement. When about to assume the pupa state, the insect forms an oval cavity at the end of its burrow, where it undergoes its transformation.

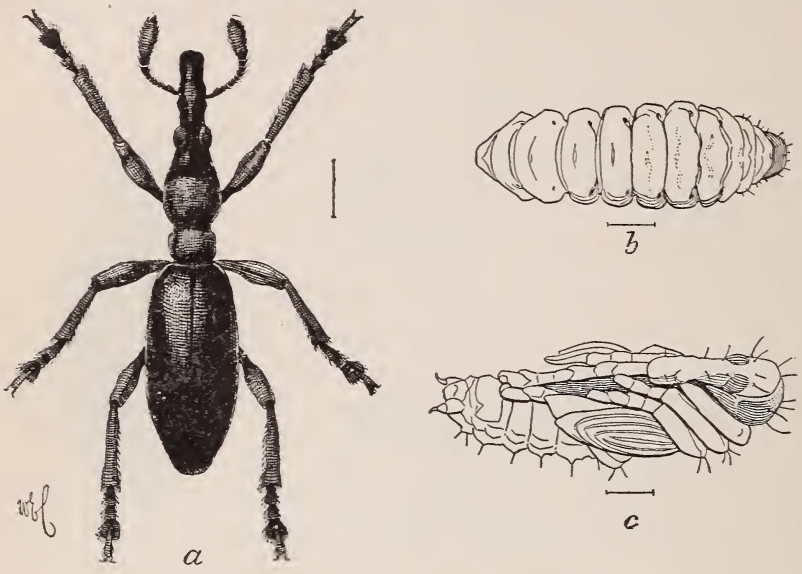

FIG. 10—Larva, pupa and adult, *Cylas formicarius* 01., a common sweet potato weevil. 7 x nat. size.

Remedies. No remedy of general application can be suggested for this pest. Infested material should be burned or destroyed with lime. In case of a serious infestation, a new location should be secured if practicable, or sweet potato growing abandoned for a time and some other crop substituted. This will materially reduce the prevalence of the weevils and in time sweet potatoes may be grown again without being infested.

MINOR PESTS.

There are a few minor pests of the sweet potato. *Nesosydne ipomoeicola* and *Aloha ipomoeae* are two common leaf hoppers on this plant. *Plusia chalcites* sometimes attacks the foliage. A mealy bug (undetermined species of Pseudococcus) and a scale insect (*Saissetia* sp.) are commonly met with, and the Japanese beetle (*Adoretus tenuimaculatus*) occasionlly attacks it and skeletonizes the leaves.

The leaf hoppers are much parasitized by Anagrus, Stylops

and Echthrodelphax and are of no importance as pests. Plusia is not very destructive and is heavily parasitized by tachinid flies. The coccids are of no great importance, and the Japanese beetle only occasionally becomes troublesome.

BENEFICIAL INSECTS.

Specific parasites have been mentioned in connection with each pest. It remains to enumerate a few general parasitic or predaceous forms. Wasps of the genus Odynerus prey on caterpillars of medium-sized Lepidoptera, which they store in nests as food for their young. Probably the commonest species at low elevation is *O. nigripennis*. The Polistes wasps also prey on these caterpillars, which they devour to obtain food for their young. The writer has found the following predaceous bugs active on the sweet potato: *Oechalia grisea, Zelus renardii* and *Reduviolus blackburni*. Oechalia attacks caterpillars and sucks out their body juice; Zelus and Reduviolus attack smaller forms —leaf hoppers, leaf miners, etc.